

Posterior approach for cervical fracture-dislocations with traumatic disc herniation

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Abstract In the treatment algorithm for cervical spine fracture-dislocations, the recommended approach for treatment if there is a disc fragment in the canal is the anterior approach. The posterior approach is not common because of the disadvantage of potential neurological deterioration during reduction in traumatic cervical herniation patients. However, reports about the frequency of this deterioration and the behavior of disc fragments after reduction are scarce. Forty patients with traumatic disc herniation were observed. They represented 29.2% of 137 consecutive patients with subaxial cervical spine fracture-dislocations. Surgical planning was performed according to our two-stage algorithm. In the first stage, they were treated with posterior open reduction and posterior spine arthrodesis. In the second stage, anterior surgery was added for cases where neurological deterioration attributed to non-reduced disc fragments on postoperative magnetic resonance imaging (MRI). Neurological deterioration after posterior open reduction was not observed. Furthermore, 25% of total cases and 75% of incomplete paralysis cases improved postoperatively by ≥ 1 grade in the American Spinal Injury Association impairment scale. Reduction or reversal of disc herniation was observed in all cases undergoing postoperative MRI. For local sagittal alignment, preoperative 9.4° kyphosis was corrected to 6.9° lordosis postoperatively. The disc height ratio was 72.4% preoperatively and 106.3% postoperatively. The second

stage of our plan was not required after the posterior approach in this series. The incidence of neurological deterioration after posterior open reduction was zero, even in cases with traumatic cervical disc herniation. Favorable clinical and radiological outcomes could be obtained by the first stage alone. Although preparations for prompt anterior surgery should always be made to cover any contingency, the need for them is minimal.

Keywords Traumatic cervical disc herniation · Cervical spine fracture-dislocations · Posterior reduction · Neurological deterioration · Pedicle screw system

Introduction

Traumatic disc herniation is frequently associated with middle and lower cervical spine injuries. Disc extrusion can occur because these injuries may cause the rupture of the posterior longitudinal ligament and posterior annulus. Previous reports have suggested that up to 40% of all fracture-dislocations of the cervical spine are associated with intervertebral disc herniation [12, 22, 24]. Traumatic cervical disc herniation is thought to cause further compression of the spinal cord and increase the risk of neurological deterioration during closed or open reduction [10, 20, 25].

According to the commonly applied treatment algorithm for traumatic cervical fracture-dislocations, an anterior or posterior approach can be used if disc fragments are not found in the canal. However, if the disc fragment is present, the only recommended approach is anterior cervical discectomy and open reduction [9, 19].

In general, anterior surgery is preferred for these patterns of injury, and has high rate of union and satisfactory

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clinical outcome [16, 18]. However, there are some drawbacks to the anterior approach: there are some cases where it is difficult to reduce the displaced cervical spine only using an anterior approach, necessitating posterior reduction [21, 23]. Moreover, data from biomechanical and clinical studies have suggested that anterior fixation provides less stability than posterior fixation [8, 14, 15, 26].

On the other hand, a few surgeons claim posterior reduction and decompression to be the optimal procedure for these injuries, because it does not have the drawbacks of the above-mentioned anterior surgery [1]. However, the potential for neurological deterioration during reduction of the disc fragment still remains.

The purpose of this study was to demonstrate the validity of the posterior approach and to assess its safety by evaluating the frequency of neurological deterioration after posterior open reduction in patients with traumatic cervical disc herniation.

Materials and methods

Study population

Forty patients, including 33 males and 7 females, with traumatic disc herniation were initially observed. They represented 29.2% of 137 consecutive patients admitted between 1995 and 2006 with subaxial cervical spinal fracture-dislocations. The mean age was 48.5 years (range 15–79 years). All 40 patients were followed up for >12 months. The mean follow-up period was 63.7 months. They were treated according to the two-stage treatment algorithm. Preoperative magnetic resonance imaging (MRI) data were obtained for all patients. Traumatic disc herniation was defined as the presence of an extruded disc deforming the thecal sac or the nerve root, and being behind the line between the postero-inferior corner of cranial vertebrae and the postero-superior corner of caudal vertebrae.

The American Spinal Injury Association (ASIA) impairment scale was used as measurement tool for neurological function and outcome.

Two-stage treatment algorithm

We proposed the two-stage treatment algorithm to benefit from the advantages of posterior surgery, while taking adequate precautions against its potential risk. Posterior surgery is applied as a first stage if the disc fragment is observed in the canal on preoperative MRI, and anterior surgery is added promptly as a second stage only if neurological deterioration occurs due to a non-reduced disc fragment.

Surgical procedure

All patients underwent posterior open reduction and spinal arthrodesis. The Axis plate system (Medtronic Sofamor Danek, USA) was used from 1995 to 2003, and a screw and rod system (OASYS; Stryker, USA) or the Vertex system (Medtronic Sofamor Danek, USA) was used after 2003. Axial traction was gently applied to the injured cervical spine using the Mayfield head holder before operation (Fig. 1). After exposure, in cases of dislocation or subluxation, a distraction force was gradually applied between the spinous processes, using bone-holding forceps, to reduce anterior translation of the proximal vertebra (Fig. 2). If reduction could not be achieved, the locked facets were released by resection of the tip of the superior articular process of the distal segment, using a high-speed burr (Fig. 3). Short segmental fixation was performed in the reduced position, with a pedicle screw system using a pedicle axis-view technique by a fluoroscope [29]. After the application of plates or rods, gentle compression was applied between the screws to approximate the facets for posterior support and promotion of facet fusion. Decortication of the facet joints and the lateral masses was performed with a burr, whereby local bone chips from spinous processes were grafted.

Postoperative treatment

The patients started ambulation and rehabilitation 1–2 days after the removal of the suction drain. They were placed in a rigid cervical collar for approximately 1 month post surgery, but no external fixation was used for patients with the ASIA impairment scale A or B.

Imaging studies

Pre- and postoperative X-rays and MRI were used. Patterns of cervical injury were classified using the Allen and Ferguson classification [2]. Local sagittal alignment and disc height ratio were measured using radiographs. “Disc

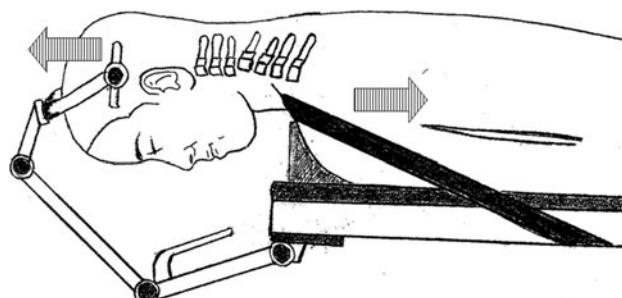


Fig. 1 Preoperative patient's body posture. Axial traction was gently applied to the injured cervical spine using the Mayfield head holder

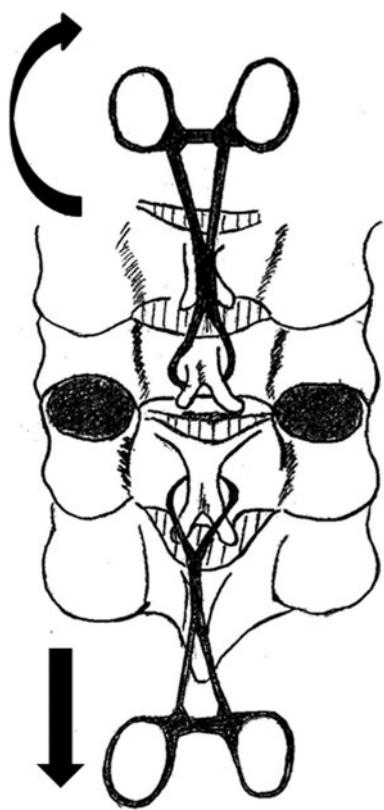


Fig. 2 A distraction force was gradually applied between the spinous processes, using bone-holding forceps, to reduce anterior translation of the proximal vertebra

height ratio” refers to the injured disc height as compared to the proximal adjacent disc height, using the methods reported by Robertson and Ryan [25]. The vertical height

of each disc was measured at the midpoint of the intervertebral overlap (Fig. 4). Alteration in the size of disc herniation was examined using the MRI images. Postoperative MRI was obtained for 23 patients (57.5%).

Results

Level of injury

The injury levels in the majority of the 137 cases were at C5-6 and C6-7. In cases associated with traumatic disc herniation, the injury level was C3-4 in 1 case, C4-5 in 6 cases, C5-6 in 7 cases, C6-7 in 22 cases, and C7-Th1 in 4 cases, with most injuries occurring at C6-7 (Fig. 5).

Cervical injury patterns

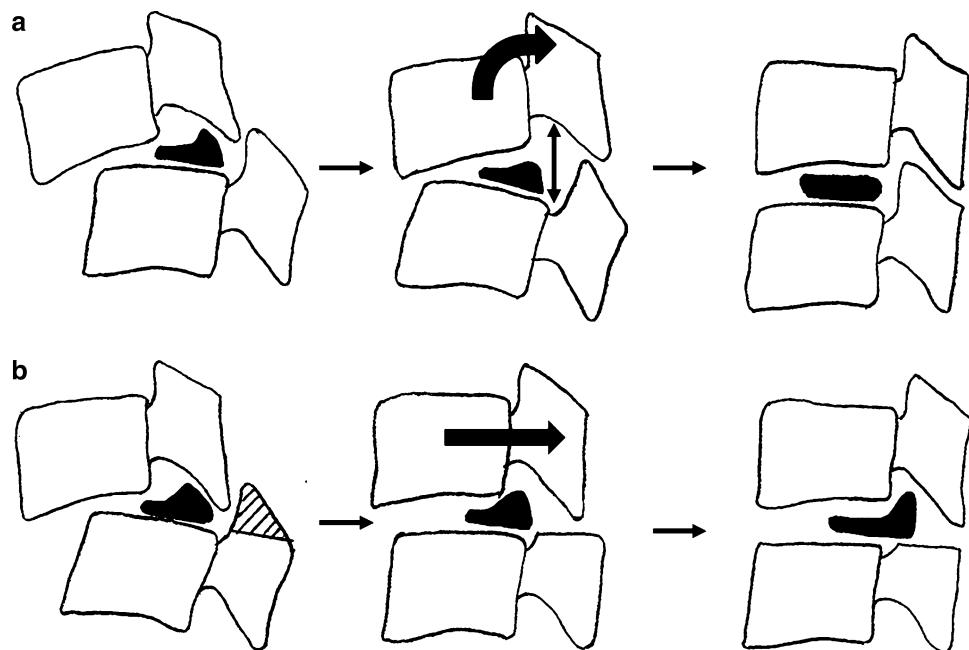
The injuries in the majority of the 137 cases were distractive flexion, compressive flexion, and compressive extension. For cases with traumatic disc herniation, 35 patients (88%) had distractive flexion (2 facet subluxation, 27 unilateral facet dislocations, 6 bilateral facet dislocation), 4 patients (10%) had compressive extension, and 1 patient (2%) had vertical compression injuries (Fig. 6).

Neurological status

The preoperative ASIA impairment scale was A, 25 cases; B, 1 case; C, 5 cases; D, 6 cases; and E, 3 cases. The postoperative ASIA impairment scale was A, 24 cases; C, 2 cases; D, 7 cases; and E, 7 cases. Neurological

Fig. 3 The possibility of neurological deterioration during reduction by traumatic disc herniation [27].

a Reduction method using distraction force. **b** Neurological damage would occur if we reduced the injured spine without distraction force in cases with disc herniation



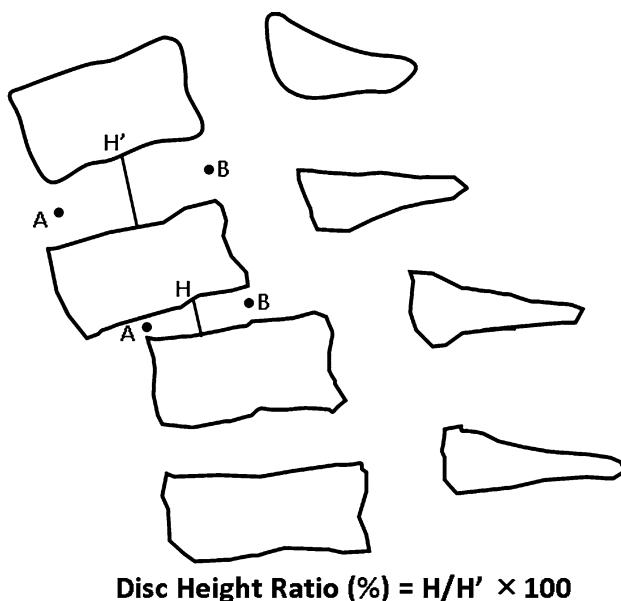


Fig. 4 The vertical height of the injured disc (H) at the midpoint of the intervertebral overlap (between A and B) was measured using the methods reported by Robertson and Ryan [25]. Value H was divided by the vertical height of the normal disc above the injury (H'), which produced a disc height ratio (%)

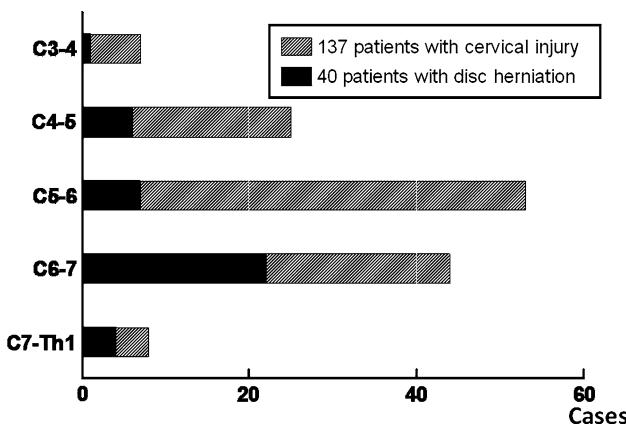


Fig. 5 Graph showing the level of injury for all 137 patients with cervical injury and the 40 cases with traumatic disc herniation

deterioration was not observed after surgery or during the follow-up period. Ten out of 40 cases (25%) and 9 of 12 incomplete paralysis patients (75%) showed postoperative improvement by more than 1 grade in their ASIA impairment scale (Table 1).

Imaging studies

Preoperative local sagittal alignment at the injured segment averaged 9.4° kyphosis (range 31° kyphosis to 8° lordosis), which was corrected to 6.9° lordosis (6° kyphosis to 21° lordosis) postoperatively, and 6.7° lordosis (6° kyphosis to 21° lordosis) at final follow-up.

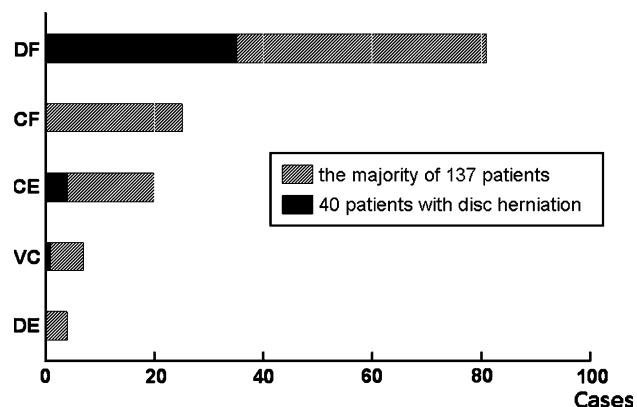


Fig. 6 Graph showing the pattern of cervical injury classified as Allen's classification, all 137 patients with cervical injury, and the 40 cases with traumatic disc herniation

Table 1 Change in the ASIA impairment scale: preoperative to postoperative

Preoperative	Postoperative				
	A	B	C	D	E
A	24			1	
B		1			
C			1	4	
D				2	4
E					3

The disc height ratio was 72.4% (40–88%) preoperatively, which increased to 106.3% (85–133%) postoperatively.

Postoperative MRI was obtained for 23 patients (57.5%). MRI showed reduction or reversal of disc herniation, with disappearance of the thecal sac and/or spinal cord compression after reduction in all cases.

Solid fusion was achieved in all cases at final follow-up.

Postoperative complications

During follow-up, instrumentation failure was detected in two cases, screw breakage and loss of correction in one case, and screw loosening in another. However, no supplemental surgery was added for them. Anterior salvage surgery was not required after the posterior procedures in these series. No neurovascular complications related to screw malposition were observed.

Illustrative cases

A 55-year-old male sustained a C5-6 bilateral facet joint dislocation (distractive flexion; Allen stage-3 classification [2]). His preoperative neurological status was ASIA-A. Preoperative MRI demonstrated extruded disc herniation at C5-6. Posterior fixation and fusion of C5-6 were conducted

using a pedicle screw system. Postoperative neurological improvement was not observed. Postoperative MRI revealed no disc herniation in the spinal canal (Fig. 7a–l).

Discussion

This study indicates that there was no incidence of neurological deterioration after posterior open reduction in cervical spine injuries with traumatic disc herniation. However, there is still no strong evidence to exclude the possibility of postoperative neurological deterioration, and thus, preparations for anterior supplemental surgery should always be made. Nevertheless, the results of this study show that favorable clinical and radiological outcomes can be obtained using the posterior approach alone.

Numerous reports concerning traumatic cervical disc herniation have been published. Even though computed tomography (CT) myelography was still the principal neuroimaging study before MRI, the reported prevalence of disc herniation with cervical spine injuries was <5%

[3, 7]. However, with the use of MRI, the reported incidence of traumatic disc herniation increased to about 40% [11, 12, 24].

There are some reports on the risk of neurological deterioration after closed or open reduction of cervical spine injuries with traumatic disc herniation. Eismont et al. [10] reported 68 cases with cervical injuries. Two cases worsened neurologically: one after failure of closed reduction and the other after posterior cervical wiring and arthrodesis. Robertson and Ryan [25] reported three patients experiencing neurological deterioration: the first after closed reduction, the second after open reduction, and the third during transfer before reduction. In both reports, the occurrence of neurological deterioration was attributed to herniated discs found on either postoperative imaging or reoperation. Olerud and Jonsson [20] described two patients found to have disc herniations after reduction on images. Both patients deteriorated after open reductions were performed, because attempts for closed reductions failed.

On the other hand, some authors have demonstrated that traumatic disc herniation does not increase the probability

Fig. 7 Imaging studies obtained in the illustrative case. Preoperative posteroanterior (a) and lateral (b) radiographs demonstrating bilateral C5–6 facet dislocation; c preoperative axial (C6 level) CT; (d) and axial (e; C5–6 level) MRI (T_2 -weighted) demonstrating extruded disc herniation at C5–6 (white arrow); postoperative posteroanterior (f) and lateral (g) radiographs showing good alignment; postoperative mid-sagittal (h) and axial (i; C5 level, j; C6 level) CT showing good alignment and good placement of pedicle screws; postoperative mid-sagittal (k) and axial (l; C5–6 level) MRI (T_2 -weighted) revealing reduction and reversal of disc herniation

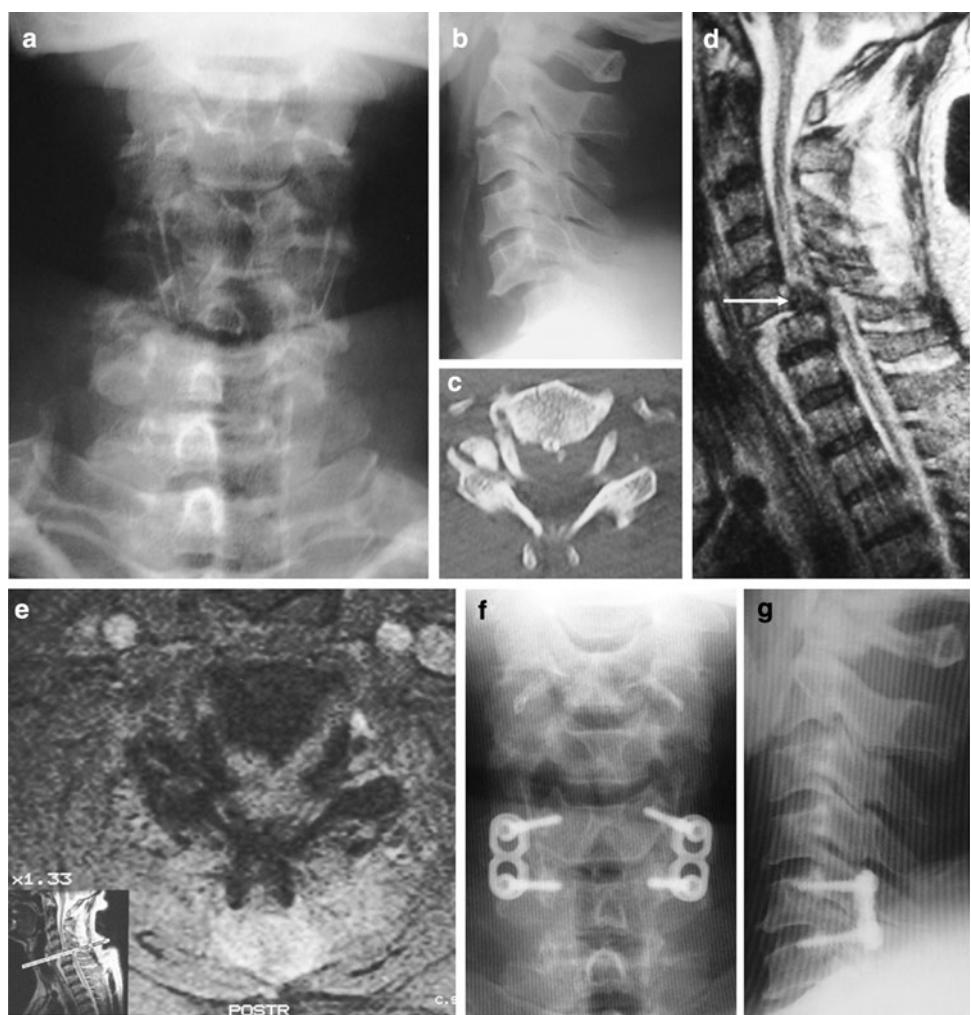
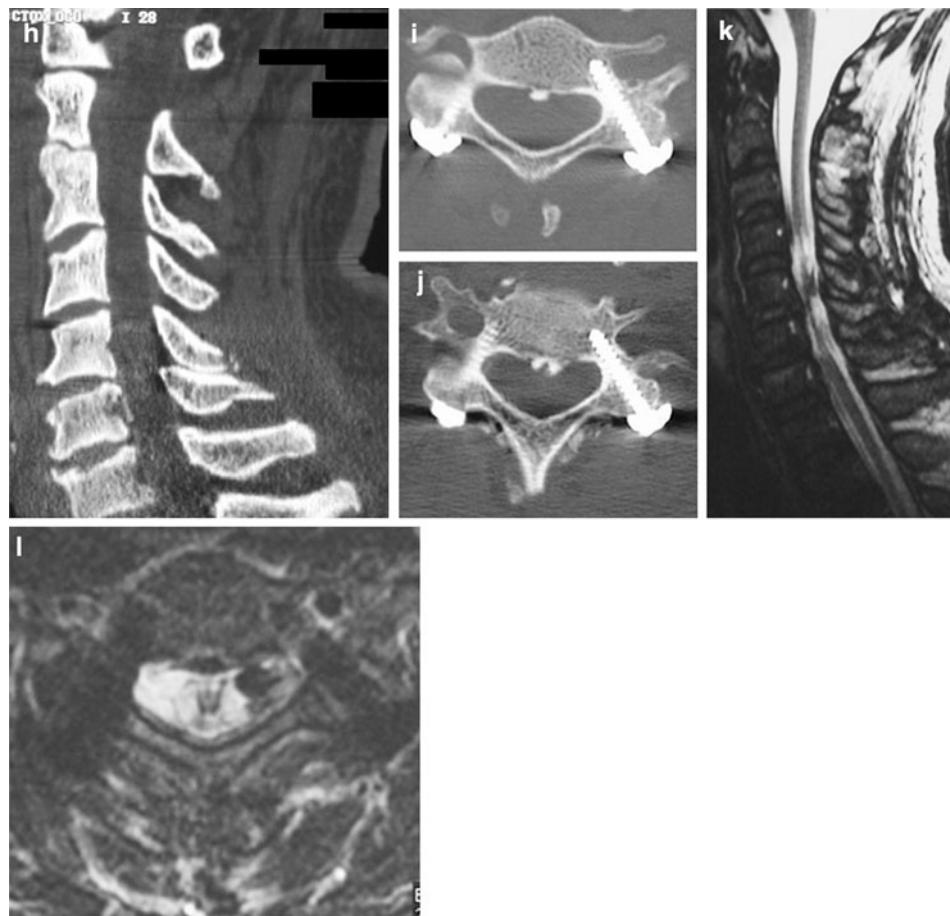


Fig. 7 continued

of neurological deterioration. Vaccaro et al. [28] studied 11 consecutive patients who underwent awake closed reduction under MRI guidance. The presence of a herniated disc on MRI did not predict neurological deterioration. No patient had neurological worsening after the procedure. Grant et al. [11] undertook postreduction MRI studies on 80 patients treated through closed reduction, and found disc herniation in 17 patients. They found no correlation between MRI results and the neurological outcome. Rizzolo et al. [24] performed MRI before reduction in 55 patients with cervical fractures and dislocations. They found evidence of disc herniation in 54% of these patients. There were no neurological deteriorations in this group.

The relationship between coexisting herniation and neurological deterioration after reduction remains controversial. The guidelines of the American Association of Neurological Surgeons [4] state that the clinical significance of disc herniation, even if demonstrated in pre-reduction MRI, is questionable. In this study, safe posterior reduction of the injured cervical spine could be achieved in cases combining disc herniation on preretraction MRI. Disc herniation is only one of numerous potential causes of neurological deterioration in patients with unstable spine

injuries. Among the other possible causes are spinal cord edema, hemodynamic instability, improper reduction and inadequate immobilization [4]. The delay in occurrence of deterioration, as described in some reports [25], raises the suspicion as to whether disc herniation is the principal factor for this complication. The prevalence of disc herniation on MRI does not always have pathological significance [6]. Further studies must be conducted to verify the relationship.

In general, the surgical results of anterior cervical spine surgeries are perceived to be favorable [16, 18]. However, the difficulties in reduction and in securing rigid fixation are the main drawbacks. In a recent study by Reindl et al. [23], 41 consecutive patients with traumatic cervical dislocations were treated using the anterior approach. The prevalence of reduction failure was 25%, necessitating supplementation by a posterior procedure. Ordonez et al. [21] studied 10 patients who underwent an anterior approach. The success rate of reduction was 90%, with 1 patient requiring a posterior approach for reduction. Jhonson et al. [14] reported 87 unilateral and bilateral facet fracture subluxations stabilized with anterior cervical discectomy, fusion, and plating. Loss of postoperative alignment occurred in 13% of the subjects.

Despite the scarcity of reports, the posterior approach eliminates these drawbacks. Reduction is less challenging and biomechanical stability can be secured by the use of pedicle screws. Abumi et al. [1] reported 16 patients with traumatic disc herniation on preretraction MRI, who were treated using a pedicle screw system. Posterior reduction could be achieved in all cases, and postoperative alignment could be maintained. Admittedly, there is a risk when using pedicle screws from C3 to C6, but cervical pedicle screw fixation has been shown to be the most stable form of cervical instrumentation fixation, obtaining a much more stable fixation than can be obtained by lateral mass screw and rod fixation [17]. With the improvement of the safety of the procedure using the pedicle axis-view method [29, 30] or navigation system [13], the risk can be minimized and, in any case, the benefits of pedicle screw use are great.

Even with the anterior approach, total excision of the injured disc before reduction is not feasible. The role of the anterior approach would be after reduction, in the attempt to relieve spinal cord or root compression that might or might not be persisting.

Thus, reduction is crucial for the anterior approach. If reduction cannot be done adequately (which is uncommon [23]), forceful anterior reduction would be risky. Posterior open reduction and anterior fixation must then be performed. This adds to the invasiveness of the procedure.

Tracheostomy is frequently needed in cases of complete paralysis in cervical injury, which might increase the risk of postoperative infection with the anterior or the combined anterior-posterior approach [5].

In both closed reduction and posterior reduction cases, the hernia cannot be removed prior to reduction. Thus, while closed reduction is certainly the more common method [4], it seems unreasonable to reject open reduction as a safe and valid method merely on the grounds that the hernia cannot be removed. Furthermore, even in cases of posterior open reduction, we apply axial traction and gently reduce the injured spine—just as with closed reduction. With the improvement of the safety of the procedure using axial traction and gentle reduction as in Figs. 1, 2 and 3, we believe that we can achieve a degree of safety as high as that with closed reduction.

Admittedly, this two-stage algorithm may be said to have limitations, in that if the neurological deterioration occurred, the time for anterior decompression would be longer. However, there is an unresolved question here: Are differences in the time for anterior decompression crucial for neurological recovery from the deterioration? In any case, preparations for prompt anterior surgery could minimize the risk of neurological damage. It should be noted that anterior surgery may also be said to have limitations, in that there is a possibility of removing a disc without pathological meaning in many cases: most of the discs on

MRI might be merely hematoma or other non-invasive materials. We have to recognize that, if anterior reduction fails, we have to perform anterior-posterior-anterior surgery, and the great invasiveness of this surgery might be too great of a burden for debilitated patients with cervical spinal cord injury. It is essential to calmly judge the advantages and disadvantages of each method.

One potential limitation of this study is that postoperative MRI was not obtained in all cases. Although there was a possibility of disc fragments being present in the canal in the 17 cases without postoperative MRI, the neurological status of these patients did not deteriorate. All cases in future studies will undergo MRI immediately after surgery.

Another potential limitation of this study is that the number of subjects with incomplete paralysis is small. To judge whether this safe result was pure luck or not, it will of course be necessary to conduct another study involving a much larger number of subjects. However, the trends observed in them are clear enough to base a provisional conclusion on.

Finally, it should be acknowledged that the anterior approach may not be the optimal procedure for all cases. Reports on the anterior and posterior approaches for the management of cases with traumatic disc herniation are still scarce. A well-structured prospective randomized control study is needed to verify the advantages and disadvantages of each approach.

Conflict of interest None.

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